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Reinforcing exercise to improve drug abuse treatment outcomes: A randomized controlled study in a substance use disorder outpatient treatment setting

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Abstract

Exercise holds potential to reduce substance use, but engaging patients in exercise regimens is challenging. Contingency management (CM) interventions can directly address adherence by targeting initiation and maintenance of exercise behavior. This study evaluated the efficacy of a CM-reinforced exercise intervention as an adjunct to standard outpatient substance use disorder treatment. Participants were 120 patients with substance use disorders who were randomly assigned to standard care with CM for completing exercise goals or CM for completing general non-exercise goals weekly for a four-month treatment period. Urine samples were tested for evidence of illicit substance use up to twice a week during treatment, and at follow-ups through 12 months. Results found that the CM-Exercise condition demonstrated during-treatment improvements on several physical activity and relevant psychosocial functioning indices (e.g., self-efficacy for exercise). CM-Exercise had no advantage relative to the CM-General condition in decreasing substance use. Overall, this study adds to a small body of well powered trials assessing effects of exercise interventions as adjunct treatment for substance use disorders and finds no benefit over an alternate CM approach in terms of drug abstinence.

Keywords

physical activity; adjuvant substance use disorder treatment; incentives

Regular physical activity (any bodily movement produced by the contraction of skeletal muscles that results in an increase in energy expenditure above resting energy expenditure) and exercise (a type of physical activity consisting of planned, structured, and repetitive bodily movement done to improve and/or maintain one or more components of physical

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fitness) have numerous health benefits, including improved executive function, self-perceived quality of life, physical functioning that enables completing daily living activities, and sleep quality, and reduced depressive symptoms, anxiety symptoms, and risk of many diseases and conditions (Pescatello, Riebe, & Thompson, 2013; Physical Activity Guidelines Advisory Committee, 2018; Powell et al., 2019). There are also biological, psychological, social and physiological reasons to expect direct and indirect benefits of physical activity and exercise on substance use (Bock et al., 2012; Brellenthin & Koltyn, 2016; Linke & Ussher, 2015; Lynch, Peterson, Sanchez, Abel, & Smith, 2013; Read & Brown, 2003; Smith & Lynch, 2013; Zschucke, Heinz, & Ströhle, 2012). For example, exercise interventions reduce negative emotional states common in patients with substance use disorders and that might precipitate relapse (Cooney et al., 2013; Wipfli, Rethorst, & Landers, 2008). Correlational and cross-sectional evidence concludes that increased physical activity is associated with reduced substance use problems (Korhonen, Kujala, Rose, & Kaprio, 2009; Ströhle et al., 2007).

Reviews generally find benefits of physical activity and exercise programs among people with licit and illicit substance use disorders. Common conclusions are that such programs are feasible and safe, and reduce anxiety and depressive symptoms (Giesen, Deimel, & Bloch, 2015; Hallgren, Vancampfort, Giesen, Lundin, & Stubbs, 2017). Empirical studies of laboratory or structured exercise interventions in adults with licit and illicit substance use disorders find reductions in cravings (Buchowski et al., 2011; Daniel, Cropley, Ussher, & West, 2004; Ussher, Sampuran, Doshi, West, & Drummond, 2004), withdrawal symptoms (Bock, Marcus, King, Borrelli, & Roberts, 1999; Taylor, Ussher, & Faulkner, 2007), and stress (Cutter et al., 2014).

Exercise interventions may also impact substance use behavior directly, but reviews are cautious. One review concluded that evidence supports increased abstinence and reduced craving or negative mood with adjuvant exercise in the treatment of illicit drug and alcohol use disorder and cigarette smoking (Wang, Wang, Wang, Li, & Zhou, 2014). Other reviews found benefits of exercise on smoking cessation (Ussher et al., 2014; Zschucke et al., 2012), but that evidence of effects on other substance use was preliminary (Zschucke et al., 2012). Reviews of studies among persons with alcohol use disorder found evidence of positive effects of exercise on fitness and other health outcomes but not on abstinence (Giesen et al., 2015; Hallgren et al., 2017). There is also general consensus that a lack of rigorous and non-preliminary studies complicates drawing conclusions (Daniel et al., 2004; Giesen et al., 2015; Hallgren et al., 2017; Ussher et al., 2014; Wang et al., 2014; Zschucke et al., 2012). Two rigorous trials in residential stimulant use disorder patients randomized to a supervised exercise program or a health education control condition found reduced relapse rates following discharge from treatment in subgroup analyses, with one finding effects on relapse only among those with low severity (18 days) stimulant use in the month prior to treatment (Rawson et al., 2015), and the other finding greater reductions in relapse rates among those with high versus low adherence to the exercise program (Trivedi et al., 2017). Adherence has also been noted as likely contributing to effects of exercise on abstinence in non-preliminary trials among alcohol use disorder outpatients (Jensen, Nielsen, & Ekstrøm, 2018; Roessler et al., 2017) and in smoking cessation studies (Marcus et al., 1999, 2005; Prapavessis et al., 2016; Ussher et al., 2015).

Low adherence to exercise regimens is a challenge, with both supervised (Ussher, Lewis, Aveyard, Manyonda, West, Lewis, Marcus, Riaz, Taylor, Barton, et al., 2015) and home-based (Ussher, Taylor, & Faulkner, 2014) programs, and even in residential settings (Trivedi et al., 2017). In fact, adherence has widespread effects on exercise and other complex behavioral health outcomes (Martin, Williams, Haskard, & Dimatteo, 2005), including in patients with stimulant use disorder, alcohol use disorder, and other chronic illnesses (Brown et al., 2014; Church et al., 2010; Dunn, Trivedi, Kampert, Clark, & Chambliss, 2005; Trivedi et al., 2017).

Contingency management (CM) is useful for increasing engagement in and outcomes of substance use treatment (Ainscough, McNeill, Strang, Calder, & Brose, 2017; Benishek et al., 2014; Lussier, Heil, Mongeon, Badger, & Higgins, 2006; Prendergast, Podus, Finney, Greenwell, & Roll, 2006). In these interventions, patients receive tangible incentives for adherence behaviors such as submitting drug negative urine samples. Reinforcement principles can also be applied toward engaging in physical activity and exercise (DeVahl, King, & Williamson, 2005; Epstein, Paluch, Kilanowski, & Raynor, 2004; Faith et al., 2001; Jeffery, Wing, Thorson, & Burton, 1998), and a meta-analysis finds reinforcement is effective for initiating and maintaining exercise (Mitchell et al., 2013). As an example, Petry et al. (2013) randomized 45 sedentary adults to a CM intervention in which they received incentives for walking 10,000 steps per day per pedometers or a control condition in which they were encouraged to meet the same step goal consistent with guidelines but without reinforcement. Participants in the CM condition met walking goals on significantly more days (82.5% versus 55.3%) than those in the control condition. However, that study did not enroll persons with substance use problems.

Two randomized studies applied CM to exercise adherence and evaluated preliminary efficacy in reducing drinking. In a non-treatment sample, Weinstock, Petry, Pescatello, & Henderson (2016) randomized 70 heavy drinking sedentary college students to 8-week interventions, one of which reinforced them for meeting objectively-verified weekly exercise goals, with the goal of increasing and then maintaining exercise over time at a level of   150 minutes per week of moderate intensity or   75 minutes per week of vigorous intensity exercise (Pescatello et al., 2013). Students in the CM condition self-reported greater exercise frequency, but changes in exercising were unrelated to drinking. In a clinical sample, Brown et al., (2014) randomized 48 alcohol-dependent sedentary outpatients to brief advice about exercising or a CM intervention, in which they received incentives for attending moderate intensity (exercise at a rate that achieved 55–69% of age-predicted maximal heart rate; Franklin, Whaley, Howley, & Balady, 2000) group aerobic exercise sessions, and 62% came to at least 8 of 12 sessions. Those in the CM intervention reduced some indices of drinking more than those receiving brief advice, but effects were not maintained at follow-up and self-reports of time spent in moderate intensity exercise and estimated maximal oxygen consumption (VO_2 max, higher values indicate greater cardiovascular health) obtained during a cardiovascular fitness test did not differ between conditions. Patients who attended aerobic exercise sessions did have improved maximal oxygen consumption, an objective measure of physical fitness that correlates with physical activity levels, and in this subgroup, correlations were significant between adherence to exercising and drinking outcomes.

Thus, exercise may hold potential as a supplemental substance use treatment intervention, but it is difficult to ascertain its impact when adherence is poor, and rigorous studies are needed. This study was a pragmatic trial to assess effects of reinforcing adherence with physical activity and exercise activities performed on a weekly basis among outpatient substance use disorder treatment patients. Exercise activities were tailored to patient preferences and abilities but aimed to increase over time and then maintain at a level of 150 minutes of moderate intensity exercise per week, per expert guidelines (Pescatello et al., 2013). The active control condition reinforced completion of non-exercise behaviors related to general treatment goals (e.g., attending a medical appointment, job skills training), to control for time, attention, and contingent reinforcement. We hypothesized that patients in the CM-Exercise condition would improve dimensions of physical activity and fitness related outcomes above and beyond their counterparts in the CM condition reinforcing completion of non-exercise goals. We evaluated relations between adherence and health outcomes. In addition, self-efficacy, motivation, and social support are associated with sustaining an exercise regimen (Buckworth, Lee, Regan, Schneider, & DiClemente, 2007; Cress et al., 2005), engaging in exercise is associated with improved quality of life in substance use disorder treatment patients (Muller & Clausen, 2015), and sleep quality improves with exercise (Kelley & Kelley, 2017). Thus, these factors were assessed. Final analyses examined study intervention effects on reducing substance use.

Methods

Participants

Participants were 120 patients enrolled in a community outpatient substance abuse treatment clinic. Inclusion criteria were age 18–65 years, English speaking, DSM-IV diagnosis of cocaine, opioid or marijuana use disorder, and written permission from a health care professional to participate in an exercise program. Exclusion criteria were: serious uncontrolled psychiatric conditions (e.g., actively suicidal, psychotic); past 6-month history of myocardial infarction, stroke, unstable angina, coronary surgery or angioplasty, uncontrolled arrhythmia, or hyperthyroidism; blood pressure >165 mmHg systolic or >95 mmHg diastolic; body mass index (BMI) >45 kg/m^2; grossly abnormal physical functioning; pregnant; or in recovery for gambling disorder. Figure 1 shows numbers screened and enrolled. The study was powered at 0.80 and alpha =.05 to detect a medium effect size between conditions of about $d = 0.50$ and enrolled ~60 patients per condition (Cohen, 1988).

Assessments

Participants provided informed consent, as approved by the University Institutional Review Board. Research staff administered baseline assessments. Participants completed checklists derived from the Diagnostic and Statistical Manual of Mental Disorders-IV (DSM-IV) to assess substance use diagnoses (American Psychiatric Association, 2000), and the Addiction Severity Index (McLellan & Hunkeler, 1998; McLellan et al., 1992) evaluated functioning across medical, employment, alcohol, drug, legal, family/social, and psychiatric domains; scores range 0 (lowest severity of problems in the domain) to 1 (highest severity of problems in the domain). An Alcosensor IV Alcometer (Intoximeters, St. Louis, MO) tested for recent drinking, and OnTrak TestSticks (Varian, Inc., Walnut Creek, CA) screened urine samples

for stimulants, opioids, and marijuana. A urine pregnancy test (EarlyPregnancyTests.com; Bellingham, WA) was administered at intake to women of childbearing potential to assess eligibility criteria.

Participants completed the International Physical Activity Questionnaire, Short Form (IPAQ) (Craig et al., 2003) which is a reliable and valid assessment of total and moderate and vigorous intensity physical activity volume in MET·mins/wk, walking for at least 10 mins in MET·mins/wk, and sitting in mins/day.

Health-related fitness and medical outcomes included the following: Handgrip, an indicator of overall body strength, is assessed in the dominant hand by a Jamar dynamometer (Lafayette Instrument Co., Lafayette, IN) and involves 2 trials to obtain average kg (Pescatello et al., 2013). The Floor Transfer Test assessed lower body strength, balance, and functional ability; it involves moving from a standing position to the floor with buttocks to the ground and returning to standing, with the quicker of two trials recorded in seconds (Murphy, Olson, Protas, & Overby, 2003). The Sit-and-Reach Test assessed low back and hip-joint flexibility (Jackson et al., 1998). Individuals sit with soles 10–12 in apart and flat against a box (32×50×45 cm) with a measuring stick placed on top of the box and extending over it towards patient's legs. The patient is instructed to slowly reach forward as far as possible toward the stick and box with both hands, keeping hands parallel and holding the furthest position for 2 sec. The score is the most distant point (in cm) reached with fingertips toward the box, with best of 3 trials recorded (ACSM, 2006; Lemmink et al., 2003). The Push-Up Test, a measure of muscle strength and endurance, recorded consecutive push-ups (Pescatello et al., 2013). A modified version of the Harvard Step Test (Keen & Sloan, 1958) assessed cardiovascular fitness. Following 5 minutes of quiet rest, individuals step onto and down from a step 30 cm (11.8 inches) in height for 3 minutes at a rate of 30 steps per minute. Heart rate is measured for 30 seconds at 1, 2 and 3 minutes after completion of stepping. A Physical Fitness Score is [(duration of exercise in seconds × 100) / (sum of the three heart rates)]. This step test has demonstrated reliability and sensitivity for assessing cardiovascular fitness (Jinzhou, Fu, Zhang, Li, & Shan, 2008). To assess blood pressure (BP) after 5 minutes of seated rest, a semiautomatic digital device (Omron, Lake Forest, IL) took at least two readings, 3 minutes apart, until consecutive readings were within 5 mm Hg and with the last two readings averaged (Pickering et al., 2005). Body mass index (BMI) was calculated from weight in kg/height in m^2.

Assessments of psychosocial functioning were: The Self-Efficacy for Exercise Scale (Resnick & Jenkins, 2000) assessed confidence about exercising regularly across various scenarios (e.g., when tired, when under pressure from work, during bad weather), with items rated 0 (*"Cannot do at all"*) to 10 ("*Highly certain can do"*), and the average taken as the scale score (range 0 to 180, least to greatest self-efficacy). The scale has good internal consistency and predictive validity and correlates with other measures of exercising (Shaughnessy, Resnick, & Macko, 2004). The Intrinsic Motivation Inventory (Buckworth et al., 2007) evaluated motivation to engage in exercise, and is reliable and valid (Lee & DiClemente, 2001; Vallerand & Fortier, 1998). Items (e.g., "I enjoy participating in physical activity very much") are rated 1 (*"Not true at all"*) to 7 (*"Very true"*), with negative items (e.g., "I participate in physical activity because I have no other choice") reverse coded, and

all item ratings summed to produce a scale score (range 21 to 147, least to greatest intrinsic motivation). Physical Activity Social Support scale has established psychometrics in evaluating support from friends and family related to physical activity (Eyler et al., 1999; Sallis, Grossman, Pinski, Patterson, & Nader, 1987; Sallis, Hovell, & Richard Hofstetter, 1992). Items ask about how often family and friends provide support in the past 2 months (e.g., "How often did my family give me encouragement to stick with me exercise program?"), with items rated 1 (*"Never"*) to 5 (*"Very often"*) (or not applicable), and the applicable items averaged to produce a Family score and a Friends score (range 13 to 65, less to more social support). The Quality of Life Inventory (Frisch, Cornell, Villanueva, & Retzlaff, 1992) assesses satisfaction in life areas. It has test-retest reliability of .80–.91, correlates with other measures of well-being (Frisch et al., 1992), and is positively impacted by CM treatments (Petry, Alessi, & Hanson, 2007). The total score (range −51 to 102) reflects subjective well-being in life domains considered to be of at least some importance to the individual, with greater scores reflecting greater well-being. The Pittsburgh Sleep Quality Index (Buysse, Reynolds III, Monk, Berman, & Kupfer, 1989) is a widely used, reliable and valid measure of sleep, with items referring to sleep quality in the past month; lower scale scores indicate better sleep quality.

Participants received $25 for completing the baseline psychosocial assessment, $25 for returning the medical form, and $25 for the baseline physical assessment. They received $50 for evaluations at Months 2, 4, 6, and 9, and $75 at Month 12. Figure 1 shows completion rates, which did not differ by conditions, $p > .05$, except for higher Month 12 completion rates in CM-Exercise, x^2 (1) values = 5.23, $p = .02$.

Procedures

All participants received standard intensive outpatient services as delivered by the outpatient clinic, which consisted of group therapy focusing on 12-steps, relapse prevention, drug refusal skills, and daily planning. Treatment involves 4 hours of care 3–4 days per week for weeks, followed by gradual reductions. By week 9, most come to the clinic for only one aftercare group session per week.

Participants submitted urine and breath samples up to twice weekly (Mon-Thur or Tues-Fri) in weeks 1–8 and once weekly in weeks 9–16. Samples were tested for marijuana, cocaine, methamphetamine, amphetamine, opioids, and alcohol as outlined above. Compensation for each sample submitted was $2, regardless of results. The research staff congratulated participants for each substance for which they tested negative and encouraged them to discuss any use in group. In addition to standard care and sample monitoring, individuals received one of two weekly CM interventions described below. The first CM session was 30–45 minutes, including explanations of how to earn incentives, and subsequent sessions were about 20 minutes.

A computerized program (Charpentier, 2003) randomized participants. It stratified assignment on Baseline sample result (positive for any drug vs none) and exercise level (< or 30 min weekly).

Treatments

CM for General Non-Exercise Behaviors (CM-General).—Persons in this condition completed a Personal Needs Assessment evaluating: employment, education, family, housing, medical/ psychiatric, legal, sobriety, social/recreational, personal improvement, and transportation concerns. They identified two to four areas, and each week, they completed Behavioral Contracts specifying activities related to those areas. For example, if the goal was education, individuals could enroll in a GED course, and if the goal was medical, they could attend a doctor's appointment. Contracts listed required objective verifications such as receipts or brochures (Petry, Martin, & Finocche, 2001). To ensure separation between conditions, exercise and physical activities (e.g., bowling, swimming, walking) were not reinforced in this condition.

Participants earned one chance to draw a slip of paper and win a prize for each contracted goal (e.g., go to an NA meeting, complete a job application) completed and verified (up to 3/ week). If they completed three goals within the week, they earned at least four bonus draws; bonus draws escalated such that if they completed three goals 2 weeks in a row, they received five bonus draws, and three goals 3 weeks in a row resulted in six bonus draws, and so on, up to a maximum of 10 bonus draws/week. In total, up to 187 draws over 16 weeks was possible.

If a patient failed to complete (or verify) three goals in a given week, draws for any completed goals were provided, but no bonus draws occurred that week and bonus draws reset to four for the next week in which at least three goals were completed. Absences required preapproval; unexcused absences reset bonus draws. Once a patient completed three goals 2 weeks in a row, bonus draws returned to the highest number previously achieved.

The prize bowl contained 500 slips. Half (250) stated "Good job!" but were not associated with a prize. The other half were winning: 204 stated "Small"; 45 stated "Large," and one "Jumbo." When individuals drew a winning slip, they chose among prizes in that category during the CM session.

Small prizes were items such as bus tokens, socks, toiletries, and food items, and large prizes were $20 gift cards, watches, coffee makers, etc. Jumbo prizes included stereos, TVs and $100 gift cards. Slips were returned to the bowl after each draw. To introduce the system, individuals could "draw until they win" (small, large or jumbo, whichever came first) in the initial CM session after determining the first behavioral contract.

CM for Exercise (CM-Exercise).—The first session explicated rationales for increasing exercise. After assessing participants most physically active period and current level with the PPAQ, staff described the American College of Sports Medicine (ACSM)) recommendations for developing and maintaining overall health and fitness (modified as needed by physician's advice) of exercising 3–5 times per week, for 30 min each time, including moderate intensity aerobic, resistance, and flexibility exercises, to total 150 minutes per week (Garber et al., 2011; Pescatello et al., 2013). They also encouraged lifestyle physical activity of household, occupational, and leisure activities (Garber et al., 2011; Pescatello et al., 2013; Physical Activity Guidelines Advisory Committee, 2018) (Blair et al, 1992; Dunn et al.,

1998), and recommended planned and short bouts (10 min) of exercising to cope with cravings. The goal was to move individuals to an equivalent of walking a 15–20 min mile pace for 2–3 miles, 3–4 days or more per week (Garber et al., 2011; Pescatello et al., 2013). Exercise programs that allow for various types of physical activities (e.g., aerobic, resistance) are recommended; and, goal setting, behavioral contracts, positive reinforcement, and having physical activity options are important for adherence to exercise programs (Cress et al., 2005).

The staff introduced the Behavioral Contract, collaboratively deciding on three physical activities each week. One initial activity included going to the YMCA, fees for which were paid by the research grant. Especially for sedentary participants, initial behavior contracts might have focused on increasing engagement in low intensity, daily physical activities, and then increased (e.g., walk 10,000 steps per day on four days this week). Documentation included workout output on the YMCA equipment, signed forms, receipts, pedometer readings, or cell phone recorded videos.

Draws earned per activity, bonus draws, and the prize bowl were identical to that above. These individuals also "drew until winning" in the first session for completing an initial contract.

Therapy adherence.—Two master's level staff provided both CM conditions. They received didactic training and completed written tests and role plays of CM, for both conditions, before study initiation. Ongoing supervision consisted of review of behavioral contracts and audiotapes. Two raters, blinded to conditions and achieving inter-rater reliability of 0.83, coded tapes from 20% of participants (selected randomly but ensuring roughly equal ratings of conditions and staff) on the Contingency Management Competence Scale for Activities (Petry et al., 2010). They rated items such as "To what extent did the therapist state how many draws would be earned at the next session if the client completed activities?" on a Likert scale (1 = not at all/ poor, 3 = somewhat/ adequate, 7 = extensive/ excellent). In CM-General sessions, means (standard deviations) were 4.9 (0.3), reflecting "good," and they were similar in CM-Exercise sessions at 5.1 (0.6), indicating competent delivery of CM in both conditions, $p > .20$. A review of all goals revealed no exercise behaviors were assigned in the CM-General condition and no non-exercise related goals were assigned in the CM-Exercise condition.

Data analysis

Chi-square and t-test tests compared conditions on demographics and Baseline variables.

The primary aim was to assess effects on physical activity, and primary outcomes were IPAQ physical activity scores. Secondary aims assessed effects on health-related fitness and psychosocial functioning measures. For changes in outcomes over time, hierarchical mixed models (HLM; Hedeker, 1993) examined effects of study condition, time, and condition by time interactions. Separate analyses examined effects during treatment (Baseline, Month 2, Month 4) and through follow-up (Baseline, Months 2, 4, 6, 9, 12). Analyses assessed linear changes over time, with time at Baseline coded zero and follow-ups coded as days from Baseline to each follow-up. For all outcomes, initial models examined effects of Time and

specified random intercepts and slopes; three models (IPAQ Vigorous activity days, Vigorous activity minutes, and Vigorous activity MET mins per week) converged only with the slope variance component fixed. After convergence, condition was added, and main (study condition, time) and interaction (condition by time) effects examined.

Exploratory aims assessed weeks in treatment and longest consecutive weeks of abstinence from alcohol, stimulants, marijuana, and opioids concurrently as measured by breath and urine samples. We also report the number of samples submitted and proportion of negative samples for all drugs concurrently. Proportions were calculated both including only submitted samples in the denominator (i.e., no assumptions about whether missing samples reflected use) and using 24 in the denominator (total expected samples, assuming missing samples were positive). Independent t-tests compared conditions on these indices, with data available from all randomized participants. Analyses other than hierarchical mixed models were conducted with IBM® SPSS® Statistics version 26.

Results

Baseline Characteristics—Table 1 shows descriptive statistics and statistical tests for variables assessed only at baseline (demographics, substance use disorder status, baseline self-reported days of substance use in the past 90 days and urine drug toxicology test results, ASI); Descriptive statistics for variables assessed repeatedly are in Table 2 (physical activity outcomes), and Supplemental Table 1 (health-related fitness, medical, and psychosocial functioning outcomes). Groups were generally similar at baseline, including no differences on most physical activity, fitness, and psychosocial outcomes. The two exceptions were Systolic BP and Diastolic BP, which were higher in the CM-Exercise condition compared to CM-General condition.

Intervention phase outcomes—Table 2 shows descriptive statistics for physical activity outcomes at each time point, and Table 3 shows associated results of hierarchical mixed model analyses. CM-Exercise participants had higher overall levels of physical activity, within-group improvements over time, and improvements over time compared to the CM-General condition on several outcomes. Specifically, Vigorous MET*mins/wk and Total MET*mins/wk were higher overall in CM-Exercise compared to CM-General. Within the CM-Exercise condition, improvements over time occurred on Moderate MET*mins/wk, Walking MET*mins/wk, and Vigorous activity days/wk; these variables did not change over time in CM-General. Condition by time interactions also occurred. Moderate activity days/wk increased over time in CM-Exercise and decreased over time in CM-General. Walking activity minutes/day increased over time in CM-Exercise and did not change over time in CM-General. Other outcomes changed similarly or did not change over time in both conditions.

For health-related fitness and medical outcomes, descriptive statistics are in Supplemental Table 1 and results of hierarchical mixed model analyses are in Supplemental Table 2. Fitness and medical outcomes were unimproved in the CM-Exercise condition compared to CM-General condition, with one exception: Floor transfer was faster (better) overall in CM-Exercise compared to CM-General. Diastolic BP and Systolic BP were higher overall in

CM-Exercise compared to CM-General, but also increased over time among CM-General participants.

For psychosocial functioning outcomes, descriptive statistics are in Supplemental Table 1 and results of analyses are in Table 4. The CM-Exercise condition conferred more benefits and protective effects on psychosocial functioning outcomes than on fitness and medical outcomes. Intrinsic motivation to exercise was higher overall in CM-Exercise compared to CM-General, and there was a significant condition by time interaction, with decreased motivation over time in the CM-General compared to CM-Exercise condition. There was also a significant condition by time interaction on Self-efficacy for exercise, which decreased over time in CM-General compared to CM-Exercise. Among CM-Exercise participants, Quality of life increased over time. These results occurred in the context of declines over time in Physical activity social support from family and Physical activity social support from friends in the CM-Exercise condition. Among CM-General participants, sleep quality decreased (improved) with time.

Most remaining intervention phase outcomes, including those related to substance use, did not differ between conditions (see Table 5). Exceptions were adherence with completing contracted goals and prize earnings, both of which were higher in CM-General compared to CM-Exercise.

Outcomes assessed baseline through Month 12 follow-up—CM-Exercise condition participants had higher overall levels of physical activity and improvements over time compared to the CM-General condition on some outcomes when assessed baseline through Month 12 (Tables 2 and 3). Walking MET*mins/week, Total MET*mins/wk, and Walking activity mins/day were higher overall in CM-Exercise compared to CM-General. Among CM-Exercise participants, Walking activity mins/day also increased over time.

Regarding health-related fitness, medical and psychosocial outcomes baseline through Month 12 (Supplemental Tables 1 and 2, and Table 4), Floor transfer was faster overall, and Diastolic BP and Systolic BP were higher overall, in CM-Exercise compared to CM-General. Meanwhile, Self-efficacy for exercise and Motivation to exercise were higher overall in CM-Exercise versus CM-General. Physical activity social support from family also decreased over time among CM-General participants. Remaining fitness, medical, and psychosocial measures changed similarly or did not change over time in both conditions.

There were no study-related serious adverse effects, but two CM-Exercise participants sustained mild injuries while exercising. Both declined medical treatment and resumed exercising after 1–4 days of rest.

Discussion

This randomized controlled trial demonstrated that reinforcing exercise in outpatient substance abuse treatment patients was efficacious in improving several physical activity indices (total physical activity and vigorous activity expenditure, volume of moderate activity and walking) and one fitness measure (push-ups) over the short term. The CM-Exercise condition also conferred protective effects against decrements in self-efficacy for

exercise and motivation to exercise observed in the CM-General condition, and increased quality of life. These effects occurred in the context of declines over time in the CM-Exercise but not CM-General condition in levels of social support for engaging in physical activity. Reinforcing exercise provided no unique or additional effect on reducing drug use relative to reinforcing other goal behaviors. The comparator condition was an enhanced intervention provided adjunct to usual care, but one that likely did not obscure effects of reinforcing exercise on abstinence. A prior study in cocaine and heroin use disorder patients assessed effects of a similar CM-General condition and found that abstinence did not differ from that observed in a standard care condition (Petry et al., 2006). This study did not compare CM for exercise to standard care alone or exercise without CM, and thus did not assess the efficacy of CM per se. This study assessed the relative efficacy of different behavioral targets of reinforcement, and the results do not indicate an advantage of reinforcing exercise over other goal behaviors of the type examined here in improving substance use outcomes. Reinforcing exercise did result in improvements in several physical activity and psychosocial functioning outcomes, consistent with findings in nonclinical samples of positive impacts of physical activity on over 35 chronic diseases and health conditions (2018 Physical Activity Guidelines Advisory Committee, 2018).

This study is the first well-powered study to assess effects of CM for exercise tailored to individual preferences and based on promising findings in prior CM studies (Brown et al., 2014; Weinstock et al., 2016). Personal preferences were accommodated in both conditions, and all participants were encouraged to select meaningful and desired activities. CM-Exercise condition participants were encouraged to select types of physical activities they most enjoyed, such as walking, bowling, attending fitness classes, or using specific exercise equipment. Likewise, individuals in the CM-General condition elected to work on individualized steps related to, for example, finding a job, improving relationships, or addressing legal problems. Adherence was higher with these non-exercise behaviors than with those involving exercise. Exercise adherence in this study compares favorably with that observed in two preliminary trials on CM for exercise among substance use treatment patients (Brown et al., 2014; Weinstock et al., 2016). Still, some patients may benefit from interventions that directly address motivation to exercise (Weinstock et al., 2016). On the other hand, rates of physical activity in this study were fairly high, even at baseline. Participants in this study sat on average five to six hours per day, and did about 3 hours of walking per day, perhaps related to the high rates of unemployment and low rates of car ownership in this sample.

Low exercise adherence is often cited as contributing to a lack of observed effects of exercise on substance use outcomes. This study aimed to address this issue by reinforcing exercise activities, and did not find differences between conditions on substance use outcomes. Focusing on studies not limited by weaknesses discussed above, two trials compared supervised group-based moderate intensity exercise to a health education control condition in residential stimulant use disorder treatment patients, and did not find overall differences between conditions on abstinence following treatment discharge (Rawson et al., 2015; Trivedi et al., 2017). However, post hoc analyses found increased abstinence among patients with high versus low exercise adherence (Trivedi et al., 2017), and in those with low severity (< 18 days) stimulant use prior to treatment (Rawson et al., 2015). Two studies in

alcohol use disorder outpatients found no differences between supervised group-based vigorous exercise or individual vigorous exercise (Jensen et al., 2018), or between supervised group or individual exercise (intensity not prescribed (Roessler et al., 2017) compared to usual alone. One of those studies noted that diminished exercise adherence over time likely contributed to results (Jensen et al., 2018). The other found that in the overall sample, moderate compared to low levels of exercise was associated with lower rates of post-treatment excessive drinking; adherence was not assessed (Roessler et al., 2017). Among sedentary women smokers, supervised vigorous exercise (Marcus et al., 2005), but not supervised moderate exercise (Marcus et al., 1999), improved smoking outcomes relative to psychosocial treatment without exercise. In the former, those with high versus low adherence had improved outcomes (Marcus et al., 2005). However, a trial in pregnant smokers did not find that vigorous exercise improved smoking outcomes compared to behavioral support only; a median 29% of sessions were attended (Ussher et al., 2015). Others assessed effects of exercise for maintenance of smoking cessation in nonpregnant women, and found no benefits of exercise relative to a contact control condition; on average, 53.8% of exercise sessions were attended (Prapavessis et al., 2016). The current study is the first assessment of exercise for treating substance use disorder that did not restrict participation to individuals with a specific substance use disorder, and results resembled those among persons selected for specific substance use disorders, discussed above.

The comparator condition in this study reinforced completion of general goal-related activities excluding exercise. This comparator controlled for differences between groups in attention, a known problem in this literature (Giesen et al., 2015). A similar condition also did not improve abstinence relative to usual care in prior research (Petry et al., 2006). Nonetheless, reinforcing exercise compared to treatment as usual might be most likely to show positive effects of the intervention on abstinence. A yoked design might also be considered, but yoked conditions have never shown benefits in CM studies (Lussier et al., 2006; Prendergast et al., 2006) and require some violations of random assignment. This study also did not test effects of reinforcing exercise on exercise adherence. Substantial evidence demonstrates that reinforcement increases adherence with target behaviors, but effects of unobserved factors cannot be ruled out.

Many individuals elected not to participate in this study (Figure 1), primarily because they did not want to exercise (i.e., self-selection), and some participants in the CM-Exercise condition failed to complete even one week of physical activities. Substance use disorder outpatients (Abrantes et al., 2011) and residential treatment patients (Stoutenberg, Warne, Vidot, Jimenez, & Read, 2015) express positive attitudes toward exercise incorporated into treatment, as do current and ex-heroin users about exercise in general (not in the context of treatment) (Neale, Nettleton, & Pickering, 2012). In this study, an exercise intervention may have had better effects in individuals with inherent interest or proclivity toward exercising, though the need for and benefit of CM in these circumstances is questionable. Another consideration is that relatively high intensity exercise (i.e., 150 minutes of moderate activity or 75 minutes of vigorous activity per week) and high intensity of support/supervision may be needed for reductions in substance use. However, no exercise or supervision intensity has proven clearly efficacious to date. Further, recruitment data and perhaps exercise adherence results here guard against adoption of reinforcing exercise as a widely applicable strategy for

addressing drug use in outpatient substance use treatment samples. In addition, no exercise or supervision intensity has proven clearly efficacious to date.

There are study limitations to consider. Participants were drawn from a single clinic, and there was high treatment drop out (on average mid-way through the intervention period), as is typical in outpatient settings (Capoccia et al., 2011; Hoffman et al., 2011; Wickizer et al., 1994). The study was designed to be a test of CM for a heterogeneous set of substance use disorders in a real-world treatment program, where the patients served are not limited to a specific type of substance use disorder. This approach increases generalization and is consistent with compelling biopsychosocial reasons to expect the benefits of exercise to apply widely to clinical and nonclinical populations, given appropriate tailoring for personal circumstances. Findings here are consistent with studies restricted to patients with specific substance use disorders, but potential differences between substance use disorders in neurobiological contributions related to exercise and substance use (Robertson et al., 2016) or other factors cannot be ruled out. The possibility that low rates of substance use prior to and during treatment in the current study (Table 3; see also Petry et al., 2005, 2012), while not uncommon (Petry, Alessi, Marx, Austin, & Tardif, 2005; Petry, Barry, Alessi, Rounsaville, & Carroll, 2012), may have rendered reductions in drug use difficult to detect.

There are also strengths of this study. It was conducted in a community outpatient substance use treatment clinic, employed minimal inclusion and exclusion criteria, and enrolled a diverse sample, increasing generalization of the findings. The two conditions applied reinforcement similar in all respects other than the target behavior so effects of reinforcing exercise explicitly could be isolated while controlling for time and attention effects. The CM-Exercise intervention provided a free gym membership to reduce costs and allow flexibility in times, types and locations for exercising, and it engendered fairly good adherence to exercise by reinforcing it. Rigor methods were employed, such as randomization to study conditions, standard objective indices, and an intent-to-treat approach to analyses.

The results of this study, in the context of the existing literature, suggest potential future directions for this area of research. In this study, reinforcing exercise aimed to address issues related to exercise adherence often cited in the literature as limiting conclusions. This study did not assess effects of reinforcing versus not reinforcing exercise adherence. There might also be important exercise dose-related relations to consider, with critical links to adherence. To address these questions, future research might experimentally vary adherence and experimentally vary exercise intensity, while attending to adherence. There is also potential in mobile and sensing technologies (wearables, and those that attach to exercise equipment). For example, such devices might improve the process of monitoring adherence, monitoring quality of exercise, and providing feedback on criterion levels of exercise.

Conclusions

This study adds to the small but growing body of non-preliminary trials on exercise interventions among substance use treatment patients. Consistent with most such studies in this literature, this study did not find benefits of exercise on substance use outcomes. There also appears to be no substance use disorder for which exercise interventions are clearly

efficacious in reducing substance use. A consistent finding relates to observed or suspected effects of adherence on outcomes. There remains a small number of trials not limited by common methodological weaknesses and few in any one patient population in this literature, and potential experimental manipulations and devices that may advance this field of research.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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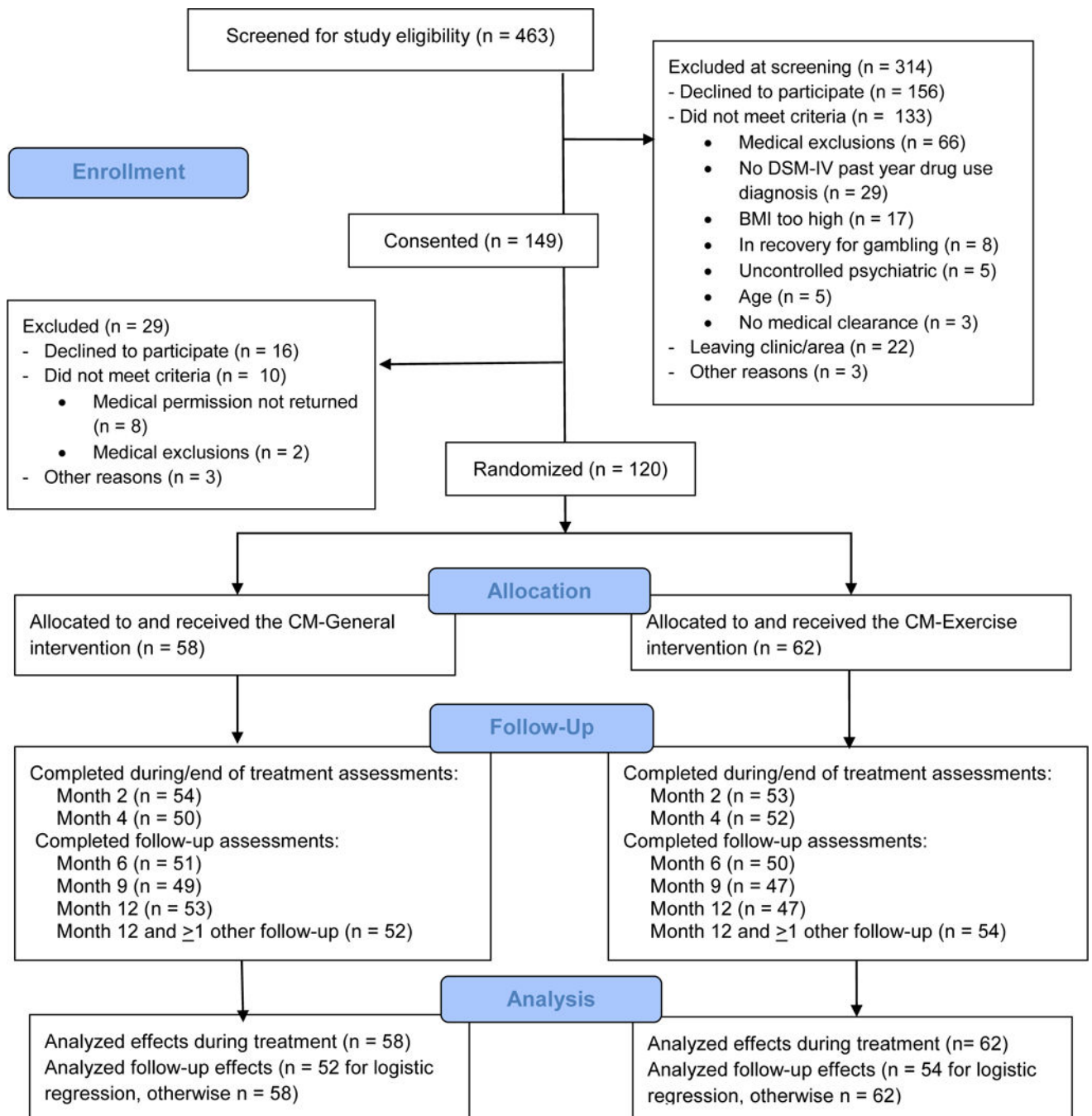
Figure.
Participant flow through the study.

Table 1.

Demographic and baseline characteristics

Variable	CM-General	CM-Exercise	Statistic test, p
N	58	62	
Age	39.3 (10.7)	36.7 (10.0)	$t(118)=1.33, .19$
Male, % (n)	74.1 (43)	77.4 (48)	$X^2 (1) = 0.18, .68$
Hispanic ethnicity, % (n)	12.1 (7)	12.9 (8)	$X^2 (1) = 0.02, .89$
Race, % (n)			$X^2 (2) = 1.51, .47$
Black or African American	41.4 (24)	37.1 (23)	
White	53.4 (31)	51.6 (32)	
Other	5.2 (3)	11.3 (7)	
Marital Status. % (n)			$X^2 (2) = 0.22, .90$
Never married	63.8 (37)	59.7 (37)	
Married/Cohabitating	15.5 (9)	17.7 (11)	
Divorced/Separated/Widowed	20.7 (12)	22.6 (14)	
Years education	12.2 (1.8)	12.6 (2.0)	$t(118)= -1.33, .19$
Any income, past 30 days, % (n)	15.5% (9)	16.1% (10)	$X^2 (1) = 0.01, .93$
Income if any, past 30 days	$700 ($648)	$723 ($1,093)	$t(118)= -0.10, .92$
Access to a car for own use, % (n)	17.2% (10)	21% (13)	$X^2 (1) = 0.27, .60$
DSM-IV diagnosis, % (n)			
Alcohol	60.3 (35)	56.5 (35)	$X^2 (1) = 0.19, .67$
Marijuana	37.9 (22)	37.1 (23)	$X^2 (1) = 0.01, .93$
Opioid	51.7 (30)	48.4 (30)	$X^2 (1) = 0.13, .72$
Stimulant	62.1 (36)	53.2 (33)	$X^2 (1) = 0.96, .33$
Baseline sample positive, % (n)			
Any substance	12.1 (7)	9.7 (6)	$X^2 (1) = 0.18, .67$
Alcohol	0.0 (0.0)	0.0 (0.0)	--
Cocaine	3.4 (2)	0.0 (0.0)	$X^2 (1) = 2.17, .14$
Marijuana	10.3 (6)	8.1 (5)	$X^2 (1) = 0.19, .67$
Methamphetamine	0.0 (0.0)	0.0 (0.0)	--
Opioids	0.0 (0.0)	1.6 (1)	$X^2 (1) = 0.94, .33$
Days of use in the past 90			
Any substance	23.7 (22.4)	26.0 (21.2)	$t(118)=-0.59, .56$
Alcohol	12.2 (19.7)	13.1 (20.1)	$t(118)=-0.27, .79$
Cocaine	6.9 (13.6)	8.2 (14.9)	$t(118)=-0.48, .63$
Marijuana	7.4 (15.6)	8.1 (16.1)	$t(118)=-0.25, .80$
Methamphetamine	1.0 (7.9)	0.2 (1.9)	$t(118)=0.77, .44$
Opioids	9.9 (18.5)	11.2 (17.6)	$t(118)=-0.42, .68$
Addiction Severity Index			
Alcohol	0.08 (0.16)	0.08 (0.16)	$t(118)=0.02, .98$
Drug	0.08 (0.09)	0.07 (0.09)	$t(118)=0.26, .80$

Variable	CM-General	CM-Exercise	Statistic test, *p*
Employment	0.83 (0.24)	0.77 (0.23)	$t(118)=1.29$, .20
Family/social	0.14 (0.19)	0.19 (0.25)	$t(118)=-1.37$, .17
Legal	0.19 (0.24)	0.17 (0.24)	$t(118)=0.49$, .63
Medical	0.14 (0.26)	0.15 (0.27)	$t(118)=-0.37$, .71
Psychiatric	0.25 (0.20)	0.22 (0.21)	$t(118)=1.02$, .31

Notes. Values are means (with standard deviations in parentheses) unless noted. CM = contingency management. Addiction Severity Index scores range 0 (lowest severity of problems in the domain) to 1 (highest severity of problems in the domain). Self-efficacy for Exercise Scale scores range 0 to 180, least to greatest self-efficacy, Intrinsic Exercise Motivation Inventory scores range 21 to 147, least to greatest intrinsic motivation. On the Pittsburg Sleep Quality Index, lower scale scores indicate better sleep quality. Physical Activity Social Support scores range 13 to 65, less to more social support. Quality of Life scores range −51 to 102, least to greatest well-being.

Table 2.

Raw means and standard deviations for physical activity outcomes at baseline through each follow-up.

Outcome	Baseline	Raw Scores					
		Month 2	Month 4	Month 6	Month 9	Month 12	
Vigorous MET·mins/wk							
CM-General	724.8 (1,237.6)	1,022.6 (1,662.7)	1,947.8 (3,069.0)	1,777.0 (2,628.2)	1,760.0 (2,956.4)	1,405.8 (2,245.8)	
CM-Exercise	834.2 (1,623.5)	2,615.7 (2,684.4)	1,913.6 (1,884.3)	2,551.3 (2,588.9)	2909.3 (3,452.7)	2,728.0 (3,141.0)	
Moderate ME·mins/wk							
CM-General	1,156.6 (1,479.2)	1,574.7 (1,584.4)	1,626.1 (1,733.8)	2,122.1 (1,825.1)	2,257.1 (1,799.8)	2,049.6 (1,881.0)	
CM-Exercise	1,360.0 (1,819.5)	1,973.7 (1,764.5)	2,338.4 (1,736.4)	2,624.3 (1,860.9)	2,881.5 (1,897.2)	2,610.0 (2,134.4)	
Walking MET·mins/wk							
CM-General	2,235.5 (1,562.7)	2,662.7 (1,517.6)	2,459.5 (1,525.3)	2,405.1 (1,602.1)	2,085.7 (1,614.2)	2,474.3 (1,664.7)	
CM-Exercise	2,536.5 (1,359.6)	3,429.1 (1,069.6)	3,216.8 (1,247.8)	3,366.0 (959.4)	3,083.1 (1,331.6)	3,044.1 (1,440.2)	
Total MET MET·mins/wk							
CM-General	4,116.9 (2,976.8)	5,260.1 (3,397.1)	6,033.4 (4,651.8)	6,304.3 (4,576.1)	6,102.8 (4,635.8)	5,929.8 (3,999.6)	
CM-Exercise	4,730.4 (3,350.5)	8,018.5 (3,959.7)	7,468.8 (3,361.9)	8,541.7 (3,971.9)	8,873.8 (5,066.7)	8,392.1 (5,577.2)	
Vigorous activity days/wk							
CM-General	1.5 (2.2)	1.8 (2.0)	1.8 (2.3)	2.0 (2.4)	1.6 (2.4)	1.6 (2.3)	
CM-Exercise	1.7 (2.3)	3.3 (2.0)	2.6 (1.9)	2.9 (2.4)	2.8 (2.7)	2.7 (2.6)	
Moderate activity days/wk							
CM-General	3.6 (2.9)	3.6 (2.5)	2.9 (2.7)	4.0 (2.6)	4.0 (2.6)	3.9 (3.0)	
CM-Exercise	2.8 (2.8)	4.1 (2.5)	4.3 (2.3)	4.3 (2.4)	4.8 (2.2)	4.4 (2.9)	
Walking activity mins/day							
CM-General	176.2 (124.0)	184.3 (122.6)	170.3 (136.6)	206.4 (171.0)	155.4 (159.7)	187.7 (146.2)	
CM-Exercise	161.9 (144.0)	255.0 (162.4)	240.5 (162.0)	244.6 (130.8)	220.4 (147.0)	241.3 (148.6)	
Sitting mins/day							
CM-General	362.3 (216.8)	277.9 (169.0)	246.0 (170.1)	254.0 (140.0)	270.5 (187.1)	285.0 (211.2)	
CM-Exercise	307.3 (187.6)	229.4 (127.1)	227.0 (142.2)	251.1 (123.5)	243.7 (191.2)	256.3 (171.0)	

Note: Walking activity days/wk captures days walked for at least 10 minutes.

Table 3.

Physical activity: Hierarchical mixed model results.

Outcome	Baseline to Month 4						Baseline to Month 12					
	Time β1	SE	T ratio[a]	P	Condition P	Condition ×Time p	Time β1	SE	T ratio[a]	P	Condition P	Condition ×Time p
Vigorous MET·mins/wk												
CM-General	10.74	3.79	2.83	.01	.02	.73	2.55	1.00	2.56	.01	.09	.41
CM-Exercise	9.11	2.83	3.22	<.01			4.01	1.45	2.77	<.01		
Moderate MET·mins/wk												
CM-General	3.85	2.68	1.44	.15	.53	.22	2.88	0.80	3.58	<.001	.17	.45
CM-Exercise	8.66	2.77	3.13	<.01			4.14	1.01	4.10	<.001		
Walking MET·mins/wk												
CM-General	1.67	2.64	0.63	.53	.14	.21	-0.11	0.78	-0.15	.88	<.01	.38
CM-Exercise	5.82	1.91	3.05	<.01			0.81	0.70	1.16	.25		
Total MET·mins/wk												
CM-General	16.66	8.39	2.45	.02	.04	.42	5.60	1.79	3.13	<.01	.02	.29
CM-Exercise	23.47	4.92	4.78	<.001			8.87	2.47	3.59	<.001		
Vigorous activity days/wk												
CM-General	<0.01	<0.01	0.78	.44	.20	.23	<0.01	<0.01	0.63	.53	.06	.66
CM-Exercise	0.01	<0.01	2.46	.02			<0.01	<0.01	1.11	.27		
Moderate activity days/wk												
CM-General	-0.01	<0.01	-1.97	.05	.11	<.001	<0.01	<0.01	1.35	.18	.98	.10
CM-Exercise	0.01	<0.01	3.49	<.001			0.01	<0.01	3.43	<.001		
Walking activity mins/day												
CM-General	-0.04	0.23	-0.18	.86	.91	.03	0.01	0.07	0.15	.88	<.01	.18
CM-Exercise	0.73	0.25	2.87	.01			0.15	0.08	1.96	.05		
Sitting mins/day												
CM-General	-0.65	0.27	-2.39	0.02	.76	.29	-0.06	0.10	-0.61	.54	.97	.43
CM-Exercise	-1.06	0.27	-3.86	<.001			-0.17	0.09	-1.93	.06		

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[a]Approximate degrees of freedom associated with 7-ratios vary with each analysis depending on number of observed vs missing data points (available from authors on request).

Note: *SE* = standard err. ß1 coefficient = the rate of change per unit time for the CM-Exercise condition when coded 0 (and CM-General coded 1); ß1 coefficient the rate of change per unit time for CM-General condition when coded 0 (and CM-Exercise coded 1). Walking activity days/wk captures days walked for at least 10 minutes.

Table 4.

Psychosocial outcomes: Hierarchical mixed model results.

Outcome	Baseline to Month 4						Baseline to Month 12					
	Time β1	SE	T ratio[a]	P	Condition P	Condition × Time p	Time β1	SE	T ratio[a]	P	Condition P	Condition × Time p
Self-efficacy for exercise												
CM-General	−0.01	<0.01	−3.01	**<.01**	.06	**.01**	<0.01	<0.01	0.82	.41	**<.01**	.33
CM-Exercise	0.00	<0.01	0.50	**.62**			<−0.01	<0.01	−0.55	.58		
Intrinsic motivation to exercise												
CM-General	−0.05	0.02	−2.02	**.05**	**.05**	**.03**	−0.11	0.08	−1.41	.16	**.03**	.43
CM-Exercise	0.02	0.02	.97	.33			−0.04	0.02	−1.87	.06		
Quality of life												
CM-General	0.05	0.04	1.28	.20	.72	.20	0.02	0.02	1.23	.22	.28	.21
CM-Exercise	0.02	0.03	3.36	**<.001**			−0.01	0.01	−0.49	.63		
Physical activity family support												
CM-General	−0.02	0.01	−0.89	.38	.43	.61	−0.01	0.00	−3.73	**<.01**	.56	.45
CM-Exercise	−0.02	0.01	−2.12	**.04**			<−0.01	0.00	−1.61	.11		
Physical activity friends support												
CM-General	−0.01	0.01	−0.47	.64	.22	.16	−0.01	<0.01	−2.88	**<.01**	.44	.74
CM-Exercise	−0.03	0.01	−2.86	**<.01**			−0.01	<0.01	−2.59	**.01**		
Sleep quality												
CM-General	−0.01	0.01	−2.41	**.02**	.67	.62	−0.07	0.07	−0.97	.33	.65	.29
CM-Exercise	−0.01	0.01	−1.78	.08			0.01	0.01	0.82	.41		

[a] Approximate degrees of freedom associated with T-ratios vary with each analysis depending on the effect considered and number of observed data points (available from authors on request).

Note: SE = standard err. β1 coefficient = the rate of change per unit time for the CM-Exercise condition when coded 0 (and CM-General coded 1); β1 coefficient the rate of change per unit time for CM-General condition when coded 0 (and CM-Exercise coded 1).

Table 5.

Retention, adherence, prize earnings, and abstinence outcomes.[a]

	CM-General	CM-Exercise	*t* (118)	*p value*
Number of weeks in treatment	8.7 (7.6)	9.3 (7.3)	−0.46	.65
Number of activities completed	32.3 (16.1)	25.7 (15.7)	2.29	**.02**
Prize earnings ($)	$248.60 ($164.40)	$179.50 ($149.90)	2.37	**.02**
Number of samples submitted	15.2 (6.5)	13.1 (7.0)	1.63	.11
Longest duration of abstinence weeks	6.2 (5.1)	4.9 (4.5)	1.40	.16
% of samples negative for all substances (of submitted samples)	81.6 (33.1)	82.4 (30.4)	−0.14	.89
% of samples negative for all substances (of 24 samples scheduled)	54.7 (32.7)	48.7 (31.4)	1.03	.31

[a]Values are mean (*SD*) unless otherwise noted.